

NAVY STTR PROPOSAL SUBMISSION

INTRODUCTION:

The responsibility for the implementation, administration and management of the Navy STTR program is with the Office of Naval Research (ONR). The Navy STTR Program Manager is Mr. John Williams, (703) 696-0342. All STTR Phase I and Phase II proposals, Phase I and II printed electronic summary reports, as well as Phase III success stories should be forwarded to Mr. Williams at the address below. If you have any questions, problems following the submission directions, or inquiries of a general nature, contact Mr. Williams. An original and four (4) copies of the Phase I proposal are due by **11 April 2001** and must be submitted to:

U.S. Mail packages send to:

Office of Naval Research
ONR 364 SBIR
Ballston Tower #2, Room 106
800 North Quincy Street
Arlington, VA 22203

Overnight Mail Services or Courier packages send to:

Office of Naval Research
ONR 364 SBIR
Ballston Tower #2, Room 106
801 North Randolph Street
Arlington, VA 22217-5660

YOUR SUBMISSION TO THE NAVY STTR PROGRAM:

This solicitation contains a mix of topics. When preparing your proposal keep in mind that Phase I should address the feasibility of the solution to the topic. Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been **invited** to submit a Phase II proposal by the Navy technical point of contact (TPOC) or the STTR program manager during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award (with the exception of Fast Track Phase II proposals per section 4.5). If you have been invited to submit a Phase II proposal, obtain a copy of the Phase II instructions from the Navy SBIR/STTR Webpage at: <http://www.onr.navy.mil/sbir> under submission. All Phase I and Phase II proposals should be sent to the Navy STTR Program Office at the above address for proper processing. Phase III efforts should also be reported to the STTR program office noted above.

The Navy will provide potential awardees the opportunity to reduce the gap between Phases I and II if they provide a \$70,000 maximum feasibility Phase I Base proposal and a fully costed, well defined \$30,000 maximum Phase I Option. **The Navy will not accept Phase I proposals in excess of \$70,000 (exclusive of the Phase I option).** The technical period of performance for the Phase I Base effort should be 6 months and for the Phase I option should be 3 months. The phase I proposal with the option will adhere to the 25 page limit (section 3.3). The Phase I Option should be the initiation of the next phase of the STTR project (i.e. initial part of Phase II), and it must be included with the Phase I proposal. Please include brief task statements and milestones for the Phase I option, and include the costs on the same Appendix C, but in a separate column.

The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The names of firms whose proposals have been selected for further consideration will be posted by topic number on the Navy SBIR/STTR website, under "What's New" within 3 months of the proposal deadline. In addition, the abstracts of

companies that have received Phase I awards will be posted on the website within 5 months of the proposal deadline.

Phase I awardees should submit a 5-page preliminary plan for Phase II to the Navy STTR Program Manager at the address above, 6 months after contract award. However, only those Phase I awardees which have been invited to submit a formal Phase II proposal will be eligible for a Phase II award (with the exception of Fast Track Phase II proposals per section 4.5). If you have been invited to submit a Phase II proposal, get a copy of the Phase II proposal preparation and submittal guidelines from the Navy SBIR/STTR website.

When you submit a Phase II proposal it should consist of three elements: 1) a \$400,000 maximum demonstration phase of the STTR project; 2) a separate 3 to 5 page transition/marketing plan describing how, to whom and at what stage you will market your technology to the government and private sector; and 3) a Phase II Option (\$100,000 maximum) which would be a fully costed and well defined section describing additional R&D or test and evaluation to assist in the transition of the technology. You must also submit your Phase II Proposal Cover Sheet, Commercialization Report, and Transition/Marketing plan electronically over the Internet at <http://www.onr.navy.mil/sbir>. Phase II proposals together with the Phase II Option are limited to 40 pages (unless otherwise directed by the TPOC or contract officer). The Transition/Marketing plan must be a separate document that is submitted through the Navy SBIR website under "Submission" and included with the proposal hard copy.

NAVY REQUIREMENTS:

- (1) The Navy requires a DoD Proposal Cover Sheet (formerly Appendix A & B) to be submitted electronically through the Navy SBIR website or DoD SBIR website at <http://www.dodsbir.net/submission>. *The company must print out the forms directly from the website, sign the forms and submit them with their proposal.* If you have any questions or problems with the electronic submission contact the DoD Helpdesk at 1-800-382-4634. Submit electronic Internet forms early. As the deadline for proposal submission approaches, computer traffic increases slowing down computer speed. **Do not wait until the last minute.**
- (2) The Navy only accepts Phase I proposals with a base effort not exceeding \$70,000 and with the option not exceeding \$30,000. The Phase I base effort should run about 6 months and the option 3 months.
- (3) All Phase I award winners must electronically submit a Phase I summary report through the Navy SBIR website at the end of their Phase I.
- (4) Phase II award winners must also submit Phase II summary reports through the Navy SBIR website.

NEW NAVY REQUIREMENTS:

- (1) All Phase II proposals must have a Proposal Cover Sheet and Commercialization Report submitted through the DoD SBIR website and a Transition/Marketing plan submitted through the Navy SBIR website.
- (2) All Phase II award winners must attend a two-day Commercialization Assistance/Business Plan Development Course from the Navy. This is typically taken at the beginning of the 2nd year of the Phase II.

ADDITIONAL NOTES:

1. The Small Business Administration (SBA) has made a determination that will permit the Naval Academy, the Navy Post Graduate School and the other military academies to participate as a Research Institution in the STTR program, since they are institutions of higher learning.
2. The Navy will allow firms to include with their proposals success stories that have been submitted through the Navy SBIR website at <http://www.onr.navy.mil/sbir>. A Navy success story is any follow-on funds that the firm has received from a past Phase II Navy SBIR or STTR award. The success story should then be printed and included as appendices to the proposal. These pages will not count towards the 25-page limit. The success story information

will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report (formerly Appendix E) and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR/STTR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR/STTR Phase II it will not count against them.

3. Effective in Fiscal Year (FY) 2000, a Navy activity will not issue a Navy STTR Phase II award to a company when the elapsed time between the completion of the Phase I award and the actual Phase II award date is eight (8) months or greater; unless the process and the award has been formally reviewed and approved by the Navy STTR Program Manager. Also, any STTR Phase I contract that has been extended by a no cost extension beyond one (1) year will be ineligible for a Navy STTR Phase II award using STTR funds.

4. The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy STTR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy will provide a 1 to 4 match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to \$250,000 in additional STTR funds can be provided as long as the Phase III is awarded and funded during the Phase II.

5. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award; and a cost plus fixed fee or an Other Transition Agreement (OTA) as a Phase II award. The type of award is at the discretion of the contracting officer.

NAVY FAST TRACK DATES AND REQUIREMENTS:

The Fast Track application must be received by the Navy 150 days from the Phase I award start date. Any Fast Track applications received thereafter may be declined. All Fast Track applications and required information must be sent to Navy STTR Program Manager at the address listed above and to the designated Contracting Officers Technical Monitor (the Technical Point of Contact (TPOC) for the contract). The dates and information required by the Navy are the same as the dates and information required under the DoD Fast Track described in the front part of this solicitation.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

1. The DoD Proposal Cover Sheet (formerly Appendix A & B) and the DoD Commercialization Report (formerly Appendix E) have been submitted electronically over the Internet through the submission site.
2. The Cover Sheet has been printed directly from website, signed, and is the first page of the proposal.
3. The Company Commercialization Report has been submitted electronically, printed, signed and attached to the back of the original and each copy of the proposal. This report is required even if the company has not received SBIR/STTR funding.
4. The Phase I proposed cost for the base effort does not exceed \$70,000. The Phase I Option proposed cost does not exceed \$30,000. The costs for the base and option are clearly separate and identified on the Proposal Cover Sheet, in the signed cost proposal, and in the work plan section of the proposal.
5. An original and 4 copies of the proposal must be received on or before 11 April 2001. The Navy will not accept late or incomplete proposals.

NAVY FY01 STTR TITLE INDEX

N01-T001 Autonomous Distributed Systems

N01-T002 Marine Mammal Detection and Mitigation
N01-T003 Outfitting Attachment Systems For Composite Sandwich Structure
N01-T004 Reconfiguration of Component Level Control Network Automation Systems
N01-T005 Oxygen Source for Underwater Vehicle Fuel Cells
N01-T006 Reduced Flammability Vinyl Ester Resin Containing no Halogens for Use in Large Composite Ship Surface Structures via Nanocomposite Technology
N01-T007 Low Cost Composite Manufacturing of Large Scale Hydrodynamic Surfaces
N01-T008 Microbubble Drag Reduction Demonstration
N01-T009 Permanent Magnets with Improved Mechanical Properties for Propulsion
N01-T010 Advanced Fluid Modeling Capability for Underwater Shock Analysis of Naval Platforms

N01-T001

TITLE: Autonomous Distributed Systems

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: FNC: Autonomous Operations

OBJECTIVE: The objective is to develop and demonstrate innovative hardware and software to enable advanced networked, autonomous, distributed systems of sensors for surveillance and measurement of the oceanic littoral environment. Sensor platforms may be fixed or mobile. The approach should be based on innovative solutions, not integration of off-the-shelf technology.

DESCRIPTION: Platforms of interest are: fleets of autonomous underwater vehicles (AUVs) sampling ocean state variables and sound speed gradients or searching for mines adaptively to minimize measurement and location error; flocks of unmanned aerial vehicles performing coastal surveillance or measuring wind speed and direction; packs of crawling robots exploring the ocean floor for mines or measuring the bottom properties; fields of fixed sensors detecting and tracking submarines and surface ships for surveillance and cooperative engagement. Autonomous here means that the units of the distributed system are not mechanically linked by communication or power cables. Typical network-class AUVs of interest are less than 200 kg in air, have a maximum speed less than 250 cm/s, can be configured to operate at full ocean depth, may be propeller, buoyancy, or fin driven, and have ranges greater than 500 km. Concepts of interest include: methods of extracting power from the environment; high bandwidth, matched acoustic and radio frequency communication devices; micro and MEMS-based sensors; tagging devices; compact packaging and deployment methods; fault tolerant network routing; distributed intelligence and control algorithms; dynamic sampling and field/target estimation methods based on fusion of global and local data. Proposals based on small, low cost, low power, modular, robust vehicles and sensors will be weighted highly.

PHASE I: The proposed concept will be designed and analyzed with particular attention to trade-offs.

PHASE II: Fabrication, testing and evaluation of a prototype will be accomplished. Cost trade-offs in production quantities should be analyzed.

PHASE III: Transition to a funded government or commercial program will be accomplished.

DUAL-USE POTENTIAL: Commercial applications include environmental modeling and prediction, satellite ground truth, marine salvage and fisheries management. The many industries associated with these activities will benefit, and this technology will likely spawn new industries.

REFERENCES:

- (1) Curtin et al., 1993. Autonomous Oceanographic Sampling Networks. Oceanography, 6(3): 86-94.
- (2) Roy, T., J. Bekkedahl, M. Hogue, M. Mayekawa, S. Hobbs, J. Herman, M. Howard, "Signal Processing and Data Fusion for Deployable Autonomous Distributed Systems", SSC SD TR-1796, March 1999, SPAWAR Systems Center, San Diego, CA
- (3) Roy, T., "Autonomous Off-Board Surveillance Sensors (AOSS) Technology Demonstration Project – FY98 Progress Report", SSC SD TR-1794, March 1999, SPAWAR Systems Center San Diego
- (4) M. Owen, P. Shea, "A Modular Fusion Architecture for Maritime Surveillance", 1999 IRIS National Symposium on Sensor and Data Fusion, 24-27 May 1999
- (5) Green, M. D., J. A. Rice and S. Merriam, "Underwater Acoustic Modem Configured for Use in a Local Area Network", Proc. IEEE OCEANS '98 Conf., Vol. 2, pp. 643-638, Nice France, September 1998

KEYWORDS: Autonomous; Sensors; Underwater; Littoral; Lightweight; Surveillance; Ultra-Low Power; Acoustic Communications

N01-T002

TITLE: Marine Mammal Detection and Mitigation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: FNC: Littoral Antisubmarine Warfare

OBJECTIVE: Enable the development of systems that will automatically detect marine mammals that may be affected by ships at sea. Develop decision aids that will guide mitigation of effects on marine mammals once detected.

DESCRIPTION: The detection of marine mammals and mitigation of effects on them during naval and commercial operations at sea is necessary in order to comply with the laws and policies which apply to marine mammals and endangered species. At present, human observers are ordinarily used to detect marine mammals at sea. Detection of distant distributions, night-time detection, detection of submerged animals and continuity and consistency of observation are problems which cannot be solved

using human observers. Possible detection systems of interest are: acoustic for detection of submerged animals; radar detection of distant distributions; optical or infrared for detection of near surface or surfaced animals. All systems must work automatically with high probability of detection and low false alarm rate. Decision Aids for mitigation of effects should take into account known behavior of marine mammals and the known handling characteristics of the ships.

PHASE I: The detection and mitigation system will be designed.

PHASE II: A prototype of the system will be constructed and shown to be feasible

PHASE III: Transition to commercial and military use will occur. Expected transition targets are the commercial oil shipping companies and the naval Anti-Submarine Warfare (ASW) community.

DUAL-USE POTENTIAL: All commercial shipping is subject to the laws and policies designed to protect marine mammals and endangered species. Commercial shipping is currently the largest killer of some endangered marine mammals. Freight and oil shipping companies are expected to benefit from the systems developed under this STTR

REFERENCES:

- (1) OPNAVINST 5090.1B, (02 FEB 1998)
- (2) SECNAVINST 5000.2B (06 DEC 1996)
- (3) "Marine Mammals and Noise", W. J. Richardson, C. R. Greene, C. I. Malme, D. H. Thomson, Academic Press, 1955
- (4) "Marine Mammals and Low-Frequency Sound: Progress Since 1995", National Research Council, National Academy Press, 2000
- (5) "Infrared Imaging Systems: Design, Analysis, Modeling and Testing VII", Holst, Gerald C. (ed.), Proceedings/SPIE—the International Society for Optical Engineering, v. 2743, 10-11 April 1996, Orlando FL
- (6) "Infrared Imaging Systems: Design, Analysis, Modeling and Testing VI", Holst, Gerald C. (ed.), Proceedings/SPIE—the International Society for Optical Engineering, v. 2470, 19-20 April 1995, Orlando, FL.
- (7) "Sensors, Cameras and Applications for Digital Photography", Sampat, Nitin (ed.), Proceedings/SPIE—the International Society for Optical Engineering, v. 3650, 27-28 January 1999, San Jose CA
- (8) "Cameras and Systems for Electronic Photography and Scientific Imaging", Anagnostopoulos, Constantine N. (ed.), Proceedings/SPIE—the International Society for Optical Engineering, v. 2416, 8-9 February 1995, San Jose CA

KEYWORDS: Marine Mammals; Automatic; Acoustic; Optical; Infra-Red; Radar; Decision Aids; Mitigation

N01-T003 TITLE: Outfitting Attachment Systems For Composite Sandwich Structure

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: FNC: Platform Protection

OBJECTIVE: Develop a system for reliably and inexpensively attaching medium to heavy weight equipment to thin-skin composite sandwich structure.

DESCRIPTION: The US Navy is utilizing or considering the use of composite sandwich materials for a variety of ship topside and hull structures. A common issue with each of these applications is the method by which equipment can be mounted to the composite panels. The desire is to introduce a single standard system that can be scaled to fit the weight of the outfitting item. The exact location of pipes, cable hangers, control boxes and other equipment is typically not specifically located when sandwich panels are fabricated. Therefore, approaches that use pre-located inserts or local core densification are not acceptable. The desired system should fit into a shipyard production environment as well as withstand the extreme environmental and combat conditions of a Navy warship.

Composite panels for Navy marine topside sandwich structures tend to optimize with relatively thin facesheets (0.10" to 0.50" for typical US Navy applications) consisting of either glass or carbon reinforced plastic composites over a balsa or foam core. Current attachment approaches include self-tapping screws, adhesive bonding, and through-bolting. Each of these approaches has distinct disadvantages and limitations. For example, self-tapping screws are limited in the maximum pull-out load that can be achieved on a thin facesheet, and final failure often involves debonding large areas of the facesheets. Through-bolting affects the backside profile of the panel and introduces a production cost associated with having workers on both sides of the bulkhead for installation. The desired solution should be scalable by weight of attached equipment and variations in sandwich panel design. Additionally the attachment method should be provided as a system to the shipyard. By 'system' it is implied that the shipyard be supplied with a total package including any tooling, adhesives, and hardware needed to apply the method.

PHASE I: Develop an attachment system and analytically demonstrate the range of application. Build prototype hardware and perform static validation testing.

PHASE II: Refine the design approach. Develop a test plan to qualify the system for shock loading over a range of weights and composite sandwich thicknesses. Develop required tools/tooling and demonstrate installation.

PHASE III: Develop a complete turn-key installation system and accompanying design manual for use in shipyards. Demonstrate application on a US Navy ship.

DUAL-USE POTENTIAL: Composite sandwich structures are prevalent in a wide range of commercial transportation industries including yachts, buses, trains and aircraft. Applications into the civil engineering sector (building and bridge applications), although not fully developed at present, are growing. Specific solutions on how to attach outfitting items to these structures are a recurring design issue.

REFERENCES:

- (1) Handbook of Sandwich Construction", Editor D.Zenkert, EMAS Publishing, 1997.
- (2) Marine Design Manual For Fiberglass Reinforced Plastics, Gibbs & Cox, Inc., sponsored by Owens-Corning Fiberglas Corporation, McGraw-Hill, New York, 1960
- (3) "Partial Inserts in Sandwich Panels - Fatigue Tests", J.Kepler, Sandwich Construction 4, Volume II, Karl-Axel Olsson Editor, Proceedings of the Fourth International Conference on Sandwich Construction, June 1998, EMAS Publishing.

KEYWORDS: Composites; Sandwich; Outfitting; Attachments; Ships; Fasteners

N01-T004

TITLE: Reconfiguration of Component Level Control Network Automation Systems

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: To reduce the latency of network reconfiguration in a distributed control infrastructure for component level based automation systems on Naval Platforms.

DESCRIPTION: A key parameter governing the cost and performance of a system with reconfiguration capability, such as a communication system with the capability of healing a damaged network, is the latency of reconfiguration (time between failure detection and fix). Different systems have different tolerance thresholds for network communications latencies. The level of redundancy required to ensure small latencies could be cost prohibitive. Healing involves some combination of overloading existing resources and/or marshalling redundant resources. By predicting where damage is likely to occur, one could utilize redundant resources to reconfigure the network in anticipation of the damage event. The objective of this would be to steer traffic away from the predicted damaged network segment. By pre-positioning network resources prior to the damage event, the processing required to determine the appropriate healing path could be reduced to a simple reconfiguration step, thus reducing damage induced latency from the healing process.

The system is a component level or device level automation infrastructure for Navy Shipboard automation, using the ANSI 709.1 control protocol.

The system employs a dependable network topology consisting of a partial mesh of network rings. Each node in the network is attached to a wire ring and the rings are connected with routers. There are redundant routers on each ring. Under normal operation the redundant routers are off-line. In the event of damage, parts of each ring may become fragmented and therefore no longer able to talk to other parts of the ring or to neighboring rings. A concept called "network fragment healing" re-configures the routers to "heal" the network. It reconnects the fragments by routing traffic through neighboring rings. This "healing" may include bringing some of the redundant routers on-line and changing the communication parameters of the nodes to reduce the traffic load. Criteria used for rerouting include load balancing and prioritization of traffic based on critical services. The logic for doing the reconfiguration is held by sentinel nodes. Reconfiguration takes time. Sentinels search the network to determine the extent of damage and paths to heal, and re-configure the routers and nodes by sending messages. While the reconfiguration is underway network traffic may be interrupted.

Simple approaches to reconfiguration treat all traffic and all nodes as equivalent. The logic for reconfiguration gets more complex as more details about the node functionality get used. At some point it becomes difficult to re-configure correctly without more comprehensive knowledge such as might be provided by a model. Moreover in the case of pre-hit configuration, it would be helpful to be able to "predict" the effects of the reconfiguration before attempting to re-configure. Thus a model of the system that determines pre-hit the likely extent of damage, will allow for reconfiguration with reduce latency.

Example: Suppose the radar systems predicts a missile will hit the ship and damage compartment A. In compartment A are several systems using the component level automation network, i.e. the chill water system and damage control sensors. Under normal operating conditions the combined traffic of all the devices in compartment A uses 25% of the bandwidth. After the hit it is expected that the damage control sensors will use 75% of the bandwidth (the damage will generate a lot of alarms and damage indications). This will saturate the channel, and drive down the channel efficiency. Damage may fragment the network and cause nodes to be isolated. The chill water system will go into war fighting mode and shed all its non-critical loads.

A pre-hit reconfiguration system would, upon reception of the expected hit notification, search for likely healing paths and re-configure the routers before the hit occurs and while the network still has sufficient reserve capacity. In addition the system might reduce traffic by re-configuring the nodes on non critical sensors and actuators by updating monitoring traffic at a slower rate, or not at all for the time required to re-configure after the hit. The time it takes to recover from the damage might be reduced enough so that the capability of the damage control system is not so adversely affected.

PHASE I: Given a pre-hit configuration for a component level automation infrastructure, design a model to predict the system state resulting from various damage scenarios, and determine the optimal pre-hit configuration that would minimize disruption of the infrastructure for each such damage scenario.

PHASE II: Develop and integrate the model into a demonstration of network fragment healing infrastructure for pre-hit configuration.

PHASE III: Refine and enhance the model and pre-hit reconfiguration for integration into a full-scale network. Extend the model to include ship systems built on automation infrastructure.

DUAL-USE POTENTIAL: Mission critical or continuous available systems such as process control, security, or transportation are severely impacted by an interruption due to damage, vandalism, or catastrophe. Pre-damage reconfiguration can ameliorate or reduce the total impact on these systems.

KEYWORDS: Automation; Network Fragment Healing; Reconfiguration; Latency; Damage Tolerance; Message Traffic

N01-T005 TITLE: Oxygen Source for Underwater Vehicle Fuel Cells

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: AN/BLQ-11 (Long Term Mine Reconnaissance System)

OBJECTIVE: Develop and demonstrate an oxygen storage and generation system capable of providing oxygen to a fuel cell power source for an underwater vehicle. The oxygen system must be safe, readily recharge or replenished, compatible with operation on surface ships and submarines, and capable of providing sufficient oxygen to operate a fuel cell over a broad power range.

DESCRIPTION: Underwater vehicles will serve as key elements in integrated operations of future surface ships and submarines, providing a range of support functions including autonomous surveillance, mine counter measures, and special forces transport. However, current power sources for these vehicles (rechargeable silver-zinc batteries or high-energy primary batteries) do not meet the energy requirements for future missions, or they impose a tremendous logistics burden on the host vessel. Fuel cells offer a viable option for meeting mission energy requirements, and at the same time, they can reduce the host vessel logistics burden if the fuel and oxidizer can be generated onboard or stored in a high energy density format.

Fuel cells operating on hydrogen or more complex fuels (such as high energy density hydrocarbons) and oxygen are attractive as underwater power sources because they are efficient, quiet, compact, and easy to maintain. The total energy delivered by a fuel cell system is limited only by the amount of fuel and oxygen available to the fuel cell energy conversion stack. Unlike ground and air transportation fuel cell systems that only require an onboard fuel, underwater vehicles must carry both the fuel and the oxygen source because the oxygen concentration in the ocean is insufficient to meet vehicle power requirements. The underwater vehicle oxygen source must possess a high oxygen content (both weight and volume based) to accommodate the weight and volume constraints of the vehicle design. On the other hand, traditional high-density oxygen sources, such as NaClO₃ candles, are not readily recharged and can easily exceed 50% of the total weight of the fuel cell system.

Therefore, innovative oxygen storage and generation systems are sought to provide gaseous oxygen for fuel cells operating in self-contained underwater vehicles. The oxygen source must be readily and rapidly recharged or replenished using gaseous oxygen, chemical or electrochemical regeneration, mechanical replacement, or other innovative approaches. The proposed system must include all components to (i) store oxygen in a safe high-density format, (ii) deliver clean oxygen at nominal fuel cell cathode operating conditions (e.g., 1 – 3 atmospheres of pressure), and (iii) accomplish rapid recharging or replenishment on

a host vessel. Oxygen generation should be capable of multiple stops/restarts and be controllable over a broad range of oxygen delivery rates. Delivery rates should be sufficient to power a typical fuel cell stack from 10 W to 10 kW (ca. 0.1 to 100 grams oxygen gas per minute). Oxygen storage capacity should be scalable to provide a minimum of 50 kilograms of useable oxygen gas. The available oxygen capacity should be maximized on a total system weight basis (i.e. weight percent oxygen), while maintaining a high volumetric density for the overall system.

PHASE I: Demonstrate a high-density oxygen storage and generation system in bench-scale experiments. Demonstrate the capability to recharge or replenish the oxygen source. Provide detailed design of an integrated oxygen system.

PHASE II: Construct and evaluate the oxygen system at the brassboard level of integration. Demonstrate controlled oxygen generation rates from 0.1 to 100 grams per hour, start/stop/restart capabilities, and recharge or replenishment capabilities. Make system available for attachment to a fuel cell for Naval laboratory testing.

PHASE III: Design and construct a fully integrated oxygen system for operation in Navy-designated undersea vehicle powered with a fuel cell.

DUAL-USE POTENTIAL: High-density oxygen storage and generation systems will make it possible to power commercial underwater vehicles with fuel cells. Rechargeable oxygen systems can be used to provide breathable oxygen for scuba diving, medical applications, emergency respirators, and aviation air supplies. Portable oxygen generators can be used to replace high-pressure oxygen cylinders for many industrial applications requiring on-site oxygen or enriched air processing.

REFERENCES:

- (1) Fuel Cell Systems, Leo J. M. J. Blomen, Michael N. Mugrewa, Ed., Plenum Publication Corp., NY (1994).
- (2) Undersea Vehicles and National Needs, National Research Council, National Academy Press, Washington D.C. (1996).
- (3) An Assessment of Undersea Weapons Science and Technology, National Research Council, National Academy Press, Washington D.C. (2000).
- (4) Russel R. Bessette, et al., J. Power Sources, 80 (1999) 248-253.
- (5) Øistein Hasvold, et al., J. Power Sources, 80 (1999) 254-260.

KEYWORDS: Oxygen; Fuel Cell; Underwater; Power; Energy; Respirators

N01-T006 TITLE: Reduced Flammability Vinyl Ester Resin Containing no Halogens for Use in Large Composite Ship Surface Structures via Nanocomposite Technology

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: DD21 (PMS 500) and Virginia class submarine (PMS 450)

OBJECTIVE: Develop a low flammability vinyl ester resin that contains no halogens and has similar processibility (viscosity, cure properties) and mechanical properties to the Navy standard vinyl ester Derakane 510A. Lower flammability includes less smoke and carbon monoxide generation and a reduced heat release rate. The suggested route for obtaining low flammability is the broadly defined 'nanocomposite' approach in which a small amount of an inflammable material (possibly inorganic) is dispersed on a nano-scale.

DESCRIPTION: The Navy is concerned with reducing the flammability of fiberglass structures through use of nonhalogenated resins. Fiberglass is used to make large structures because of processibility and low cost. Any approach taken to reduce flammability therefore must not significantly increase cost or alter processibility. The 'nanocomposite' approach shows promise. For example, the incorporation of treated clays which exfoliate into isolated sheets 2 nanometers thick and microns in length and width has been shown to greatly reduce flammability in several resin systems (ref. 1,2) It is believed that the inorganic silicate structure supports the polymer resin structure during a fire preventing flow, and as surface resin is burned away, the inflammable silicate layers form a surface layer which impedes the flow of oxygen to the remaining organic resin. Such an approach has the potential of being cheap (clay) and only slightly altering processing (use of 2-5 weight percent may be sufficient). The term 'nanocomposite' is broadly defined in this solicitation, and pertains to many morphologies beyond exfoliated clays.

The Navy standard low flammability vinyl ester resin is Derakane 510A. The goal is reduced flammability and similar or improved processing and mechanical properties from a nonhalogenated resin and at a reasonable cost.

PHASE I: Development of the resin, small scale characterization of viscosity and cure, small scale testing for flammability (such as ASTM E1354 Cone Calorimetry for heat release rate, mass loss, carbon monoxide, and smoke production), and neat mechanical properties.

PHASE II: Scale up of the resin, production of fiberglass panels, mechanical characterization, and full scale demonstration, i.e., mechanical and fire testing (such as ISO 9705 Room Corner Fire Test).

PHASE III: Commercialization through an interested third party.

DUAL-USE POTENTIAL: Fiberglass is used in the home (vanities, countertops, ladders), in vehicles, in boats, airplane interior compartments, and many other places where reduced flammability is an issue.

REFERENCES:

(1) E.P. Giannelis, Advanced Materials, 8, 29, (1996).

(2) J.W. Gilman, T. Kashiwagi, J.D. Lichtenhan, "Nanocomposites: A Revolutionary New Flame Retardant Approach", SAMPE Journal, 33(4), July/August 1997.

KEYWORDS: Nanocomposite; Vinyl Ester Resin; Fiberglass; Nonhalogenated Resin; Flame Retardant; Exfoliated Clays

N01-T007 TITLE: Low Cost Composite Manufacturing of Large Scale Hydrodynamic Surfaces

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: FNC: Total Ownership Cost Reduction

OBJECTIVE Develop low cost vacuum assisted resin transfer molding (VARTM) composite fabrication technique and design for the manufacturing of dimensionally critical hydrodynamically smooth lifting surfaces for Naval vessels.

DESCRIPTION: Large scale composite Naval applications are currently manufactured using VARTM techniques. VARTM processing typically uses one mold surface and a bag surface. For dimensionally critical structures requiring two hydrodynamic smooth surfaces, conventional VARTM is not applicable. The technique that is typically used is resin transfer molding (RTM) which uses a closed mold. Manufacturing techniques such as RTM are generally too expensive to use for large scale applications. The reason for this is that the mold that is required for RTM is typically very costly. In addition, there has been minimal experience base for manufacturing of large scale RTM parts which have surface which are 150 square feet or more. This program is looking to develop a VARTM type low cost process which can be used to manufacture structures which require high tolerances on dimensions and will have all surfaces which are smooth. In addition, optimum lifting surfaces would have angles of attack which are maintained over a large pressure loading. This requires that the lifting surfaces react to structural loading so that it experiences minimal deformation. This can be accomplished using composite materials by properly designing the laminate stacking sequence to achieve the appropriate stress couplings.

PHASE I: Conceptualize and demonstrate the ability to use a low cost VARTM process that can be used to manufacture a structure with two hydrodynamically smooth surfaces having complex curvature. In addition, provide a conceptual design that will allow a lifting surface shape to maintain an optimum angle of attack over a large pressure range. This should be demonstrated through both the manufacturing of small scale sections using the proposed VARTM technique and loading the manufactured structure to verify that the structure will have the appropriate reacting load to maintain its shape.

PHASE II: Manufacture a large scale composite lifting surface with two hydrodynamically smooth faces using the developed low cost VARTM process. Demonstrate that the structure has been designed to maintain an optimum angle of attack over a large pressure range through hydrodynamic testing of a full scale component.

PHASE III: Manufacture and qualify a full scale composite lifting surface optimized for low cost and with demonstrated property of being able to maintain optimum angle of attack. This structure will be installed on a surface ship such as a DDG-51 flight 2-A class ship for ship evaluation.

DUAL-USE POTENTIAL: The technology could be utilized to manufacture similar lifting surfaces for large ocean going vessels such as cargo and cruise ships as well as Coast Guard vessels.

REFERENCES:

(1) Gowing, Scott, Coffin, Paul, and Dai, Charles, "Hydrofoil Cavitation Improvements with Elastically Coupled Composite Materials", Proceedings of the 25th American Towing Tank Conference, Iowa City Iowa, Sept. 1998.

KEYWORDS: VARTM; Composites; Hydrodynamic Surfaces; Bending-Twisting Coupling Design

N01-T008 TITLE: Microbubble Drag Reduction Demonstration

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: FNC: Expeditionary Logistics

OBJECTIVE: An intermediate to large scale sea-borne implementation of microbubble drag reduction (MBDR) is desired to determine scale-up and seawater effects on the efficacy of the technique, as well as on bubble and ejection parameters, and robustness in at-sea conditions.

DESCRIPTION: The injection of microbubbles into a turbulent boundary layer has been demonstrated to reduce frictional drag up to 80% in laboratory scale tests. Though the speeds of the tests have been as high as 50 knots, the models were small, and the tests were conducted in fresh water. As scale is increased to that of sea-going vessels, the usefulness of the technique is unknown. It is desirable to perform tests of MBDR on larger sea-going platforms at speeds sufficiently high to approach or exceed a Reynolds number of 2×10^8 . A length of at least 10 meters is desired. Hydrofoil and SWATH configurations would be particularly attractive since friction is the predominant drag contribution in those cases. Measurements of flow and microbubble variables at these larger scales are needed to establish a knowledge-base sufficient for design.

PHASE I: A laboratory demonstration of a microbubble injection technique based on present knowledge and scaled up for a sea-borne platform implementation will be required. A platform will need to be identified, and a detailed design of the at-sea test system will need to be completed, including alterations to the platform. Instrumentation will need to be designed or selected to measure the expected drag reduction and MBDR parameters with adequate resolution and accuracy as exhibited in an uncertainty analysis.

PHASE II: At-sea trials on the selected platform will be conducted to determine the performance of the MBDR system. Bubble injection parameters and platform operation, such as speed, turns, seastate, etc., will be varied to develop a database of performance. Measurements of drag reduction and other variables, such as air flowrate, plenum pressure, and bubble distribution, will be performed. A total system energy balance, including air pumping will be performed.

PHASE III: Both the Navy and the commercial sector are expected to be highly interested in this technique if found to be feasible at ship scale because of increasing interest in the reduction of fuel consumption. Existing and near future hydrofoil, SWATH, and similar configurations would be expected to be the initial target of application since frictional drag is relatively more important for these configurations. Future larger sealift ships of similar design are also envisioned.

DUAL-USE POTENTIAL: The growing market for high-speed ferries would be the prime initial commercial target for MBDR application. Many of these utilize configurations which could benefit from a successful application of drag reduction. Larger ships would benefit eventually if the technology proves to be useful and adaptable to more conventional hull-forms.

REFERENCES:

- (1) Madavan, M.K., Deutsch, S. and Merkle, C.L., "Measurements of local skin friction in a microbubble-modified turbulent boundary layer," J. Fluid Mech. V.156, 1985.
- (2) Deutsch, S., and Castano, J., "Microbubble skin friction reduction on an axisymmetric body", PSU/ARL-TM-85-139 , available in DTIC as ADA247709, www.dtic.mil.
- (3) Marie, J.L., "A simple analytical formulation for microbubble drag reduction", Physicochemical Hydrodynamics V.8 no.2, 1987.

KEYWORDS: Microbubble; Drag Reduction; Ship; Hydrofoil; SWATH; Demonstration

N01-T009 TITLE: Permanent Magnets with Improved Mechanical Properties for Propulsion

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop rare earth-based, high energy product permanent magnets with improved toughness for motors for ship and underwater vehicle propulsion. Advances in bonding of magnets to structural components, improved adhesion of protective coatings, and improved mechanical stability, all of which depend on improved toughness of the magnets, are desired in order to improve the performance and reduce the cost and weight of permanent magnet motors. These properties are also desired for magnetic levitation applications such as electromagnetic launch and recovery systems for aircraft.

DESCRIPTION: Permanent magnet motors offer several advantages for ship propulsion. Eliminating brushes improves reliability and reduces maintenance. Concepts such as the integrated motor-propulsor, where a permanent magnet rotor serves as the propeller, offer reduced size and weight in addition. High performance rare-earth-based permanent magnets can provide very

high energy densities, i.e. both large effective fields and good resistance to demagnetization. However the hard magnetic phase in these magnets is an intermetallic compound which is brittle and susceptible to oxidation. Recent proposals to combine the hard magnet phase with a high magnetization iron-based phase to increase the energy product, might also lead to improved toughness. These magnets need to be coated to protect them from the corrosive salt-water environment, and they must be bonded to the rotor (or stator) structure material. Improved toughness is needed to insure the integrity of these bonds. If the magnets could be shaped into desired motor structures, and if their mechanical properties were sufficient for them to provide part of the strength of the structure, it would be possible to reduce the purely mechanical components of the motor.

PHASE I: Identify materials and/or processing schemes and demonstrate that they provide improved toughness of currently available permanent magnets, with equal or improved energy product.

PHASE II: Optimize composition and microstructure to maximize toughness. Demonstrate improvements in bonding to structural materials, adhesion of coatings, or mechanical stability of shaped propulsor blades in realistic test environment.

PHASE III: The improved magnet material will be incorporated into a permanent magnet motor or an integrated motor-propulsor demonstration.

DUAL-USE POTENTIAL: Permanent magnet motors are used in commercial appliances, and in automotive applications.

REFERENCES:

(1) Technological properties of permanent magnets are discussed in the yearly proceedings of the Intermag Conference, which are published in the IEEE Transactions on Magnetics.

KEYWORDS: Permanent Magnets; Rare Earth Magnets; Toughness; Mechanical Stability; Coatings; Permanent Magnet Motors

N01-T010 TITLE: Advanced Fluid Modeling Capability for Underwater Shock Analysis of Naval Platforms

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: FNC: Platform Protection; MCM

OBJECTIVE: Develop and implement advanced fluid modeling capability for use in underwater shock analyses to support design optimization of ship and submarine hull structures

DESCRIPTION: Ship and submarine platforms must be designed to withstand nearby detonations of underwater weapons such as mines and torpedoes. The detonation of an underwater weapon produces a complex loading from the shock wave and gas bubble from the detonation products, which interacts with the surrounding water, the sea bottom, the water surface, and any other nearby surfaces. Accurate prediction of the development and propagation of the loading to the platform is essential for assessing the response of the platform. More accurate load prediction for complex, real world environments will facilitate the optimization of structural hull designs and hull protection systems, resulting in lighter and more survivable hull configurations.

PHASE I: Demonstrate the applicability of advanced fluid modeling techniques such as level set methods to solve underwater shock benchmark problems.

PHASE II: Implement the advanced fluids solver into software packages currently in use for ship and submarine shock analysis. Validate against relevant test data. Apply new capability to optimize passive ship hull protection systems.

PHASE III: Transition new capability to Navy simulation development programs and ship/submarine hull design programs. Apply the new capability to support the design of passive hull protection systems, resulting in more affordable, lighter, and more survivable hull designs.

DUAL-USE POTENTIAL: Advanced fluid solvers will be implemented in design tools for a variety of commercial applications. These include (i) oil rig demolition, (ii) mitigation of explosion effects on structures and marine life during harbor construction and demolition, (iii) understanding fluid flow issues in hydraulic machinery and reactor systems, (iv) addressing seakeeping and maneuverability issues (waveloading effects) for large commercial vessels, and (v) design of commercial double hulled tankers.

REFERENCES:

(1) Hansen, Ib, They Must Be Sturdy, Proceedings of the U.S. Naval Institute, pp. 50-54, October 2000.

KEYWORDS: Underwater Explosions; UNDEX; Euler Modeling; Free Surfaces; Fluid Modeling; Shock Analysis